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# FEE TRANSMITTAL for FY 2004

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☐ Applicant Claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT \$500.00

## Complete if Known

Application Number	10/081,074
Filing Date	02/21/2002
First Named Inventor	LOPATIN
Examiner Name	FOURSON III, GEORGE R.
Art Unit	2823
Attorney Docket No.	0180199 (Previously P1406)

## METHOD OF PAYMENT (check all that apply)

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## FEE CALCULATION

## 1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee (\$)	Small Entity Fee Code	Small Entity Fee (\$)	Fee Description	Fee Paid
1001	770	2001	385	Utility filing fee	
1002	340	2002	170	Design filing fee	
1003	530	2003	265	Plant filing fee	
1004	770	2004	385	Reissue filing fee	
1005	160	2005	80	Provisional filing fee	

SUBTOTAL (1) (\$)

## 2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

Total Claims	Extra Claims	Fee from below	Fee Paid
Independent Claims	-20**=	X	
Multiple Dependent	-3**=	X	

Large Entity Fee Code	Large Entity Fee (\$)	Small Entity Fee Code	Small Entity Fee (\$)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	86	2201	43	Independent claims in excess of 3
1203	290	2203	145	Multiple dependent claim, if not paid
1204	86	2204	43	**Reissue independent claims over original patent
1205	18	2205	9	**Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) (\$)

\*\* or number previously paid, if greater; For Reissues, see above

## FEE CALCULATION (continued)

## 3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee (\$)	Small Entity Fee Code	Small Entity Fee (\$)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet	
1053	130	1053	130	Non-English specification	
1812	2,520	1812	2,520	For filing a request for ex parte reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	420	2252	210	Extension for reply within second month	
1253	950	2253	475	Extension for reply within third month	
1254	1,480	2254	740	Extension for reply within fourth month	
1255	2,010	2255	1,005	Extension for reply within fifth month	
1401	500	2401	250	Notice of Appeal	
1402	500	2402	250	Filing a brief in support of an appeal	\$500.00
1403	290	2403	145	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive - unavoidable	
1453	1,330	2453	665	Petition to revive - unintentional	
1501	1,330	2501	665	Utility issue fee (or reissue)	
1502	480	2502	240	Design issue fee	
1503	640	2503	320	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	770	2809	385	Filing a submission after final rejection (37 CFR 1.129(a))	
1810	770	2810	385	For each additional invention to be examined (37 CFR 1.129(b))	
1801	770	2801	385	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

Other fee (specify)

\*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) \$500.00

## SUBMITTED BY

## Complete (if applicable)

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

**Sergey Lopatin**

Serial No.: 10/081,074

Filed: February 21, 2002

For: **Chemical Solution for Electroplating a  
Copper-Zinc Alloy Thin Film**

Art Unit: 2823

Examiner: Fourson III, George R.

**APPEAL BRIEF**

Mail Stop Appeal Brief - Patents  
Honorable Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir/Madam:

This is an Appeal from the Examiner's Final Rejection of claims 1-10, 21-22, and 25-30. The Final Rejection issued on October 6, 2004. The Notice of Appeal was filed in the U.S. Patent and Trademark Office on December 29, 2004.

02/08/2005 HDEMESS1 00000034 10081074

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### **REAL PARTY IN INTEREST**

The real party in interest is Advanced Micro Devices, Inc.

### **RELATED APPEALS AND INTERFERENCES**

There are no related Appeals or Interferences.

### **STATUS OF CLAIMS**

Claims 1-10, 21-22, and 25-30 are pending, and claims 11-20 and 23-24 were canceled in previous amendments. Claims 1-10, 21-22, and 25-30 have been finally rejected in a Final Rejection dated October 6, 2004. This Appeal is directed to the rejection of claims 1-10, 21-22, and 25-30. Claims 1-10, 21-22, and 25-30 appear in an Appendix to this Appeal Brief.

### **STATUS OF AMENDMENTS**

No claim amendment has been filed in response to the Final Rejection dated October 6, 2004.

### **SUMMARY OF CLAIMED SUBJECT MATTER**

#### **A. Claim 1**

Independent claim 1 recites a method for fabricating a semiconductor device having a copper-zinc alloy (Cu-Zn) film (e.g. Cu-Zn alloy thin film 30) on a copper (Cu)

surface (e.g. Cu surface 20) by electroplating the Cu surface in a chemical solution. Page 8, lines 4-7 and Figures 1 and 3 of the present application. At step (1) of the method (e.g. method M2), a semiconductor substrate having a Cu surface (e.g. Cu surface 20) is provided. Page 8, lines 8-9 and Figures 1 and 3 of the present application. For example, the Cu surface (e.g. Cu surface 20) may be formed by chemical vapor deposition (CVD), plasma vapor deposition (PVD), plasma-enhanced vapor deposition (PECVD), or electroplating. Page 8, lines 5-7 and Figure 1 of the present application. At step (2) of the method (e.g. method M2), a chemical solution is provided, where the chemical solution comprises at least one zinc (Zn) ion source for providing a plurality of Zn ions, at least one copper (Cu) ion source for providing a plurality of Cu ions, at least one complexing agent for complexing the plurality of Cu ions, at least one pH adjuster, and at least one wetting agent for stabilizing the chemical solution. Page 8, lines 9-13 and Figure 3 of the present application. The at least one wetting agent is provided in a concentration range of approximately 0.01 g/L to approximately 0.1 g/L and dissolved in a volume of deionized (DI) water. Page 5, lines 4-6 and 12-13, and page 7, lines 19-22 of the present application.

At step (3) of the method (e.g. method M2), the Cu surface (e.g. Cu surface 20) is electroplated in the chemical solution to form a Cu-Zn alloy film (e.g. Cu-Zn alloy thin film 30) on the Cu surface, where the chemical solution does not etch the Cu surface (e.g. Cu surface 20). Page 4, lines 8-9 and page 7, lines 13-15 and Figures 1 and 3 of the present application. By not etching the copper layer, the filling capability of the Cu-Zn

electroplating solution (i.e. the chemical solution) is advantageously enhanced. Page 4, lines 2-9 of the present application. At step (4) of the method (e.g. method M2), the Cu-Zn alloy film is rinsed in a solvent, and at step (5) the Cu-Zn alloy film (e.g. Cu-Zn alloy thin film 30) is dried under a gaseous flow, such as a gaseous nitrogen flow (GN<sub>2</sub>). Page 8, lines 15-17 and Figures 1 and 3 of the present application. The Cu-Zn alloy film (e.g. Cu-Zn alloy thin film 30) formed in the above method (e.g. method M2) has a de minimum Zn content in a concentration range of at least approximately 0.1 at.% to approximately 1 at.%. Page 8, lines 1-3 of the present application.

By providing a desirably low Zn content in a Cu alloy interconnect, the present invention's Cu-Zn electroplating solution (i.e. chemical solution) advantageously provides a minimal increase in resistance as well as a maximum improvement in electromigration resistance. Page 4, lines 13-16 of the present application. Also, by providing superior fill-characteristics, the present invention's Cu-Zn electroplating solution (i.e. chemical solution) advantageously improves Cu interconnect reliability, enhances electromigration resistance, improves corrosion resistance, and reduces manufacturing costs. Page 3, lines 23-26 and page 4, line 1 of the present application.

#### **GROUND OF REJECTION TO BE REVIEWED ON APPEAL**

- A. Claims 1-10, 21-22, and 25-30 stand rejected under 35 U.S.C. §103 as being unpatentable over U.S. Patent Application Publication No. 2002/0127847 A1 to Alling et al. (hereinafter "Alling") in combination with U.S. Patent No. 6,398,926

B1 to Lotar Peter Mahneke (hereinafter “Mahneke”), U.S. Patent No. 3,706,635 to Xavier Kowalski (hereinafter “Kowalski”), and U.S. Patent No. 6,486,533 B2 to Krishnamoorthy et al. (hereinafter “Krishnamoorthy”).

## **ARGUMENT**

### **A. Rejection of Claims 1-10, 21-22, and 25-30 under 35 U.S.C. §103 over Alling, Mahneke, Kowalski, and Krishnamoorthy**

For the reasons discussed below, Appellant respectfully submits that the present invention, as defined by independent claim 1, is patentably distinguishable over Alling, Mahneke, Kowalski, and Krishnamoorthy, singly or in any combination thereof.

In contrast to the present invention as defined by independent claim 1, Alling does not teach, disclose, or suggest providing a chemical solution, where the chemical solution comprises at least one wetting agent provided in a concentration less than 0.1 g/L and dissolved in a volume of deionized water, electroplating a Cu surface in the chemical solution to form a Cu-Zn alloy film on the Cu surface, where the chemical solution does not etch the Cu surface, rinsing the Cu-Zn alloy film in a solvent, and drying the Cu-Zn alloy film under a gaseous flow, where the Cu-Zn alloy film has a zinc content in a concentration less than 1.0 atomic %. Alling specifically discloses electroplating a second metal layer, which may comprise a Cu-Zn alloy, over a first metal layer, which may comprise Cu, where the second metal layer is substantially less conductive than the first metal layer. See, for example, Alling, page 2, paragraph [0022] and page 3,

paragraphs [0028] and [0029]. In Alling, the resistivity of the second metal layer is at least about 10 percent greater and more preferably at least about 20 to 500 percent greater than the first electrically conductive layer (e.g. copper layer). See, for example, Alling, page 3, paragraph [0028]. In contrast, independent claim 1 recites a Cu-Zn alloy film having a zinc content in a concentration less than 1.0 atomic %, which, as discussed above, provides a minimal increase in resistance in a Cu alloy interconnect. Thus, Alling fails to teach, disclose, or remotely suggest a Cu-Zn alloy film having a zinc content in a concentration less than 1.0 atomic %, as specified in independent claim 1. Furthermore, since, in Alling, the second metal plated, such as a copper alloy, is preferably substantially less conductive than the first metal plated, such as a copper layer, Alling provides no motivation for providing a Cu-Zn alloy film having a zinc content in a concentration less than 1.0 atomic %.

In Alling, an electroplating bath includes wetting agents in an amount of 0.1 to 20 g/L, and preferably 0.5 to 10 g/L. See, for example, Alling, page 4, paragraph [0045]. However, Alling fails to teach, disclose, or suggest at least one wetting agent in a concentration less than 0.1 g/L, as specified in independent claim 1. In Alling, an electrolytic plating bath is provided that contains components admixed in water. See, for example, Alling, page 5, paragraph [0057]. However, Alling fails to teach, disclose, or suggest at least one wetting agent dissolved in a volume of deionized water, as specified in independent claim 1. Also, Alling fails to teach, disclose, or suggest the step of rinsing the Cu-Zn alloy film in a solvent or the step of drying the Cu-Zn alloy film under a

gaseous flow, as specified in independent claim 1. Thus the electroplating process taught in Alling is substantially different than the Cu-Zn alloy film formation process specified in independent claim 1.

Mahneke is relied on by the Examiner for providing motivation to enable the formation of the copper-zinc alloy film of Alling to be performed and obtain further advantage of preventing contamination on both surfaces of the wafers. Page 4 of the Final Rejection dated September 16, 2003. Mahneke is directed to an electroplating chamber that allows substrates such as wafers to be effectively plated with the plating surface facing upwards. See, for example, the Abstract of Mahneke. Mahneke generally discloses that an electroplating process typically involves surface preparation, plating, rinsing, and drying steps, where the rinsing and drying steps are often required for both the top and bottom surfaces of the wafer to prevent contamination. See, for example, Mahneke, column 1, lines 25-38. Mahneke also discloses that the wafer may be dried by blow drying of nitrogen or other gases. See, for example, Mahneke, column 5, lines 29-35. Thus, Mahneke discloses general steps of an electroplating process, which are performed through the use of Mahneke's electroplating apparatus. However, Mahneke fails to teach, disclose, or remotely suggest using a process that uses a single plating bath to deposit two different metals at differing current densities or reduction potentials, as disclosed in Alling. See, for example, the Abstract of Alling.

Thus, Mahneke is directed to the operation and use of a particular electroplating apparatus while Alling is directed to a specialized electroplating process that uses a single



plating bath to deposit two different metals. Mahneke discloses a typical electroplating process only for the purpose of illustrating the operation of an electroplating apparatus. As such, the requirements of the specialized process disclosed in Alling are substantially unrelated to the typical electroplating process disclosed in Mahneke. Thus, the combination of Alling and Mahneke proposed by the Examiner simply is not based on sufficient evidence of reason, suggestion, or motivation in the prior art that would have led one of ordinary skill in the art to make such a combination. Thus, Mahneke fails to cure the basic deficiencies of Alling discussed above.

Kowalski is relied on by the Examiner as providing motivation to enable the step of admixing the chemical solution with a volume of water of the combination process to be performed. Page 5 of the Final Rejection dated September 16, 2003. Kowalski is directed to processes for the electrodeposition of metals and processes for the preparation of media which may be employed in the electrodeposition or electroplating of metals. See, for example, Kowalski, column 1, lines 3-6. Kowalski specifically discloses an example in which twenty-two tests were conducted in order to show the cooperative effect of HEDP (1-hydroxy, ethylidene-1,1-diphosphonate) and EDTMP (ethylenediamine tetra(methylene phosphonate) ligands in the electrodeposition of metals from an electroplating solution containing such ligands, as contrasted to the utilization of these ligands on an individual basis. See, for example, Kowalski, column 10, lines 10-15. In the above example, the twenty-two tests were prepared in deionized water. See, for example, Kowalski, column 10, lines 16-18. Thus, Kowalski discloses a plating solution

comprising HEDP and EDTMP ligands, which may be prepared in deionized water.

However, Kowalski fails to teach, disclose, or suggest a chemical solution comprising at least one wetting agent that is dissolved in a volume of deionized water, as specified in independent claim 1. Furthermore, Kowalski does not teach, disclose, or suggest any particular purpose for utilizing deionized water to prepare the plating solution comprising HEDP and EDTMP ligands.

Also, Kowalski discloses an electroplating solution comprising HEDP and EDTMP ligands for electroplating of alloys by the use of two or more different metals capable of a chelate formation. See, for example, Kowalski, column 3, lines 49-52. In contrast, Alling discloses a completely different electroplating process that does not use HEDP and EDTMP ligands to form chelates. Thus, the combination of Alling, Mahneke, and Kowalski proposed by the Examiner simply is not based on sufficient evidence of reason, suggestion, or motivation in the prior art that would have led one of ordinary skill in the art to modify the above references as suggested by the Examiner. Rather, the suggested combination of Alling, Mahneke, and Kowalski proposed by the Examiner is based on impermissible hindsight reconstruction given the benefit of the Appellant's disclosure.

Krishnamoorthy is relied on by the Examiner as providing motivation to enable the formation of the chemical solution of the combination process to be performed and obtain further advantage of solving the diffusion and self-passivation problems in metallization structure. Page 5 of the Final Rejection dated September 16, 2003. Krishnamoorthy is

directed to a metallized structure for use in a microelectronic circuit. See, for example, the Abstract of Krishnamoorthy. Krishnamoorthy specifically discloses metallization structure 20 including ultra-thin film bonding layer 35 disposed exterior to dielectric layer 25, copper-zinc alloy layer 40 disposed exterior to ultra-thin bonding layer 35, and an optional primary conductive layer 45 disposed exterior to copper-zinc layer 40. See, for example, column 4, lines 30-36 and Figure 1 of Krishnamoorthy. In Krishnamoorthy, ultra-thin bonding layer 35 has a thickness of between 10 and 20 Angstroms and principally functions as an adhesion promoter to bond copper-zinc alloy layer 40 to dielectric layer 25. See, for example, column 4, lines 44-50 and Figure 1 of Krishnamoorthy. In Krishnamoorthy, copper-zinc alloy layer 40 can have a preferable zinc content below about 2 atomic percent. See, for example, Krishnamoorthy, column 5, lines 27-28.

In Krishnamoorthy, a copper-zinc alloy layer (e.g. copper-zinc alloy layer 40) is formed having a desirably low zinc concentration to reduce the resistivity of the alloy layer. See, for example, Krishnamoorthy, column 5, lines 34-36. In contrast, as discussed above, Alling specifically discloses electroplating a second metal layer, which may comprise a Cu-Zn alloy, over a first metal layer, which may comprise Cu, where the second metal layer is substantially less conductive than the first metal layer. In Alling, the two materials (i.e. two layers) are preferably of sufficiently distinct resistivity so that the first deposited material can effectively transmit an electric signal and the second material will act as a resistive layer. See, for example, Alling, page 2, paragraph [0022].

Furthermore, in Krishnamoorthy, a less conductive layer (e.g. copper-zinc alloy layer 40) is formed on ultra-thin bonding layer 35 and a more conductive layer (e.g. primary conductive layer 45) is formed on the less conductive layer. In contrast, in Alling the less conductive layer (i.e. higher resistivity layer) is deposited on the more conductive layer (i.e. lower resistivity layer). Thus, the resulting structure formed in Krishnamoorthy is substantially different than the resulting structure formed in Alling.

Furthermore, the copper-zinc alloy layer (e.g. copper-zinc alloy layer 40) in Krishnamoorthy is used for solving diffusion and passivation problems. See, for example, Krishnamoorthy, column 3, lines 1-3. In contrast, the less conductive alloy layer (i.e. the second layer) disclosed in Alling has a higher resistivity to allow an electrical signal to be transmitter through the more conductive layer (i.e. the first layer) without migration or electrical defects or the like into the second layer. See, for example, Alling, page 2, paragraph [0016]. Thus, for the above reasons, Appellant respectfully submits that the Examiner has disclosed insufficient motivation for the suggested combination of Alling and Krishnamoorthy.

Considered together, the collective teachings of Alling, Mahneke, Kowalski, and Krishnamoorthy do not and cannot result in the present claimed invention. The purported teachings suggest by the Examiner (i.e. the combined teachings of Alling, Mahneke, Kowalski, and Krishnamoorthy) are not based on sufficient evidence of reason, suggestion, or motivation in the prior art that would have led one of ordinary skill in the art to make the suggested modifications. Rather, the reasons, suggestions, and

motivations for the modifications proposed by the Examiner are based on hindsight reconstruction given the benefit of the Appellant's disclosure, which is impermissible.

For the foregoing reasons, Appellant respectfully submits that the present invention, as defined by independent claim 1, is not suggested, disclosed, or taught by Alling, Mahneke, Kowalski, and Krishnamoorthy, singly or in combination thereof. As such, the present invention, as defined by independent claim 1, is patentably distinguishable over Alling, Mahneke, Kowalski, and Krishnamoorthy. Thus, claims 2-10, 21-22, and 25-30 depending from independent claim 1 are, *a fortiori*, also patentably distinguishable over Alling, Mahneke, Kowalski, and Krishnamoorthy for at least the reasons presented above and also for additional limitations contained in each dependent claim.

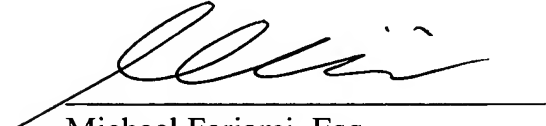
### **CONCLUSION**

Based on the foregoing reasons, the present invention, as defined by independent claim 1 and claims depending therefrom, is patentably distinguishable over the art cited by the Examiner. Thus, claims 1-10, 21-22, and 25-30 pending in the present application are patentably distinguishable over the art cited by the Examiner. As such, and for all the foregoing reasons, an early allowance of claims 1-10, 21-22, and 25-30 pending in the present application is respectfully requested.

This Appeal Brief is submitted herewith with an Appendix of the appealed claims and the requisite fee for filing the Appeal Brief.

Respectfully Submitted,  
FARJAMI & FARJAMI LLP

Date: 2/1/05

  
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**APPENDIX OF CLAIMS ON APPEAL**

**Claim 1:** A method of fabricating a semiconductor device, having a copper-zinc alloy (Cu-Zn) film formed on a copper (Cu) surface by electroplating the Cu surface in a chemical solution, comprising the steps of:

providing a semiconductor substrate having a Cu surface;

providing a chemical solution, wherein the chemical solution comprises at least one wetting agent for stabilizing the chemical solution, wherein the at least one wetting agent is provided in a concentration less than 0.1 g/L, wherein the at least one wetting agent is dissolved in a volume of deionized (DI) water;

electroplating the Cu surface in the chemical solution, thereby forming a Cu-Zn alloy film on the Cu surface, wherein the chemical solution does not etch the Cu surface;

rinsing the Cu-Zn alloy film in a solvent;

drying the Cu-Zn alloy film under a gaseous flow;

wherein the Cu-Zn alloy film has a zinc (Zn) content in a concentration less than 1.0 atomic %.

**Claim 2:** A method, as recited in Claim 1, wherein the chemical solution is nontoxic and aqueous, and wherein the chemical solution comprises:

at least one zinc (Zn) ion source for providing a plurality of Zn ions;

at least one copper (Cu) ion source for providing a plurality of Cu ions;

at least one complexing agent for complexing the plurality of Cu ions; and  
at least one pH adjuster, all being dissolved in the volume of deionized (DI) water.

**Claim 3:** A method, as recited in Claim 2, wherein the at least one zinc (Zn) ion source comprises at least one zinc salt selected from a group consisting of zinc acetate  $((\text{CH}_3\text{CO}_2)_2\text{Zn})$ , zinc bromide  $(\text{ZnBr}_2)$ , zinc carbonate hydroxide  $(\text{ZnCO}_3 \cdot 2\text{Zn}(\text{OH})_2)$ , zinc dichloride  $(\text{ZnCl}_2)$ , zinc citrate  $((\text{O}_2\text{CCH}_2\text{C}(\text{OH})(\text{CO}_2)\text{CH}_2\text{CO}_2)_2\text{Zn}_3)$ , zinc iodide  $(\text{ZnI}_2)$ , zinc L-lactate  $((\text{CH}_3\text{CH}(\text{OH})\text{CO}_2)_2\text{Zn})$ , zinc nitrate  $(\text{Zn}(\text{NO}_3)_2)$ , zinc stearate  $((\text{CH}_3\text{CH}_2)_{16}\text{CO}_2)_2\text{Zn}$ , zinc sulfate  $(\text{ZnSO}_4)$ , zinc sulfide  $(\text{ZnS})$ , zinc sulfite  $(\text{ZnSO}_3)$ , and their hydrates.

**Claim 4:** A method, as recited in Claim 2,  
wherein the chemical solution further comprises at least one complexing agent for complexing the plurality of Zn ions being dissolved in the volume of DI water,  
wherein the at least one complexing agent for complexing the plurality of Zn ions comprises tartaric acid  $(\text{HO}_2\text{CCH}(\text{OH})\text{CH}(\text{OH})\text{CO}_2\text{H})$ , and  
wherein the tartaric acid prevents precipitation of the plurality of Zn ions from the chemical solution.

**Claim 5:** A method, as recited in Claim 2, wherein the at least one copper (Cu) ion source comprises at least one copper salt selected from a group consisting of copper(I)



acetate ( $\text{CH}_3\text{CO}_2\text{Cu}$ ), copper(II) acetate ( $(\text{CH}_3\text{CO}_2)_2\text{Cu}$ ), copper(I) bromide ( $\text{CuBr}$ ), copper(II) bromide ( $\text{CuBr}_2$ ), copper(II) hydroxide ( $\text{Cu}(\text{OH})_2$ ), copper(II) hydroxide phosphate ( $\text{Cu}_2(\text{OH})\text{PO}_4$ ), copper(I) iodide ( $\text{CuI}$ ), copper(II) nitrate hydrate ( $(\text{CuNO}_3)_2$ ), copper(II) sulfate ( $\text{CuSO}_4$ ), copper(I) sulfide ( $\text{Cu}_2\text{S}$ ), copper(II) sulfide ( $\text{CuS}$ ), copper(II) tartrate ( $(\text{CH}(\text{OH})\text{CO}_2)_2\text{Cu}$ ), and their hydrates.

**Claim 6:** A method, as recited in Claim 2,

wherein the at least one complexing agent for the plurality of Cu ions comprises at least one species selected from a group consisting of ethylene diamine "EDA" ( $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ ) and ethylenediaminetetraacetic acid "EDTA" ( $(\text{HO}_2\text{CCH}_2)_2\text{NCH}_2\text{CH}_2\text{N}(\text{CH}_2\text{CO}_2\text{H})_2$ ), and

wherein the at least one complexing agent for the plurality of Cu ions prevents precipitation of the plurality of Cu ions from the chemical solution.

**Claim 7:** A method, as recited in Claim 2, wherein the at least one pH adjuster comprises at least one pH-adjusting compound selected from a group consisting of ammonium hydroxide ( $\text{NH}_4\text{OH}$ ) and tetramethylammonium hydroxide "TMAH" ( $(\text{CH}_3)_4\text{NOH}$ ).

**Claim 8:** A method, as recited in Claim 1, wherein the at least one wetting agent comprises a surfactant, and wherein the surfactant comprises at least one material selected

from a group consisting of RE-610<sup>TM</sup> and polyethylene glycol (PEG).

**Claim 9:** A method, as recited in Claim 1,

wherein the Cu surface is formed by a process selected from a group consisting of chemical vapor deposition (CVD), plasma vapor deposition (PVD), plasma enhanced chemical vapor deposition (PECVD), electroplating, and electroless plating,

wherein said solvent comprises water, and

wherein said gaseous flow comprises gaseous nitrogen (GN<sub>2</sub>).

**Claim 10:** A method, as recited in Claim 2,

wherein the at least one zinc (Zn) ion source is provided in a concentration range of approximately 5 g/L to approximately 25 g/L,

wherein the at least one complexing agent for complexing the plurality of Zn ions is provided in a concentration range of approximately 10 g/L to approximately 30 g/L,

wherein the at least one copper (Cu) ion source is provided in a concentration range of approximately 5 g/L to approximately 25 g/L,

wherein the at least one complexing agent for complexing the plurality of Cu ions is provided in a concentration range of approximately 40 g/L to approximately 100 g/L,

wherein the at least one pH adjuster is provided in a concentration range of approximately 10 g/L to approximately 20 g/L,

wherein the volume of DI water is provided in a volume range of up to and

including 1 L,

wherein the at least one pH adjuster adjusts the chemical solution to a pH in a range of approximately 7.5 to approximately 14,

wherein the chemical solution is maintained at a temperature in a range of approximately 16°C to approximately 35°C,

wherein the Cu surface is immersed for a time duration in a range of approximately 15 seconds to approximately 120 seconds, and

wherein the Cu-Zn alloy film is formed having a thickness in a range of approximately 10 nm to approximately 200 nm.

**Claim 21:** The method of Claim 2 wherein the at least one complexing agent comprises ethylenediaminetetraacetic acid "EDTA"  $((\text{HO}_2\text{CCH}_2)_2\text{NCH}_2\text{CH}_2\text{N}(\text{CH}_2\text{CO}_2\text{H})_2)$ .

**Claim 22:** The method of Claim 2 wherein the at least one pH adjuster comprises tetramethylammonium hydroxide "TMAH"  $((\text{CH}_3)_4\text{NOH})$ .

**Claim 25:** The method of Claim 2 wherein:  
the at least one zinc (Zn) ion source is provided in a concentration range of approximately 5 g/L to approximately 25 g/L; and  
the at least one copper (Cu) ion source is provided in a concentration range

of approximately 5 g/L to approximately 25 g/L.

**Claim 26:** The method of Claim 2 wherein the at least one pH adjuster adjusts the chemical solution to a pH in a range of approximately 7.5 to approximately 14.

**Claim 27:** The method of Claim 2 wherein the at least one pH adjuster adjusts the chemical solution to a pH in a range of approximately 10 to approximately 12.

**Claim 28:** The method of Claim 2 wherein the at least one copper (Cu) ion source comprises copper(II) sulfate ( $\text{CuSO}_4$ ).

**Claim 29:** The method of Claim 2 wherein the at least one zinc (Zn) ion source comprises zinc dichloride ( $\text{ZnCl}_2$ ).

**Claim 30:** The method of Claim 2 the at least one complexing agent comprises ethylene diamine "EDA" ( $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ ).